SCIENCE

NEW SERIES
VOL. LXIII, No. 1642

FRIDAY, JUNE 18, 1926

ANNUAL SUBSCRIPTION, $6.00
SINGLE COPIES, 15 CTS.

SCIENCE

VOL. LXIII JUNE 18, 1926 No. 1642

CONTENTS

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. McKeen Cattell and published every Friday by

THE SCIENCE PRESS

Lancaster, Pa. Garrison, N. Y.

New York City: Grand Central Terminal.

Annual Subscription, $6.00. Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

Entered as second-class matter July 18, 1923, at the Post Office at Lancaster, Pa., under the Act of March 8, 1879.

THE CHOICE OF A PROFESSION—MEDICAL[1]

IN accepting the kind invitation of Professor Hartson to address you to-day I was fully conscious of my inability to place before you a complete picture of the possibilities of medicine as a career. As a matter of fact, the field of medicine has become so broad that even those possessed of the maturity, wisdom and experience of a long life devoted to medicine in its widest purposes would find it difficult to speak with authority on any but a limited aspect of the question at hand. It is, nevertheless, true that any university teacher in medicine must have a sufficiently general knowledge of the topic to outline to you the general scope of medicine, and at the same time depict to you the aim, ambitions and rewards that are common to those working in the many diverse fields of this profession. I am, therefore, very grateful for this opportunity.

Medicine is that science which relates to the prevention, cure or alleviation of disease. Undoubtedly in most ancient times it dealt purely with the alleviation of suffering. Doubtless it had at that time the closest possible relation with religion, for disease, even down to recent times, was looked upon as a visitation by an evil spirit. The cure was obvious—the evil spirit was either bought off or chased away. As mankind became civilized, certain diseases were seen to recur regularly and in each instance to cause the same symptoms, and a true medical science developed, and the devil was relieved of another undeserved opprobrium. Soon a connection was seen with external conditions, and man learned a little regarding the prevention of diseases and began to study the conditions under which the body was most likely to remain free from disease. By the fourth century before Christ medicine had become a learned profession, and in the writings of Hippocrates, that great leader of the School of Cos and usually spoken of as the "Father of Medicine," we find not only a very clear description of many diseases but lengthy discourses concerning the conditions under which the body can be kept in good health and disease prevented.

In view of this it may seem extraordinary that quackery, miracle healing and a very diversified number of medical cults exist and flourish even to-

[1] Address to the senior class of Oberlin College, May 25, 1925, as an exercise in a course covering vocational guidance.

day. We should recall, however, that there are three parasites which have clung to each successive stage of civilization—quackery, drunkenness and prostitution. These parasites have maintained vigor, persistence and superiority over all the efforts of church, state and society; quackery, chiefly because of human gullibility.

Since, as a science, medicine deals with the prevention and treatment of disease, it is obvious that its chief efforts are devoted to a study of the causes of disease. Thus in modern medicine—that is, since the time of Louis Pasteur—the greatest efforts have been directed towards the classification and study of bacteria and the results they produce, since it is now known that a great proportion of all diseases is caused by the invasion of the body by bacteria. There has grown, as a result of this, an almost separate science—*bacteriology*. It is the workers, in this and allied fields, that are responsible for our finding out that certain bacteria when they grow produce a toxin or poison, and that in turn an antitoxin or something to counteract the poison may be made outside the body and then injected into people sick with an infection by a particular bacterium. The accessions to medical knowledge from this field have been productive of the greatest benefit to mankind.

But medicine is not so simple that a knowledge of the causes of disease will assure us an immediate remedy. In the first place bacteria are not the cause of all forms of disease; and tumors, disorders of the brain and many great groups of diseases may have a quite different etiology. There are still many groups of diseases the causes of which are entirely unknown. However, even if the causes of all diseases were known, there would still be much more to medicine, chiefly perhaps because of the variations in individuals. No two people are either built exactly alike nor do they react the same to similar stimuli. This, indeed, is one of the reasons why medicine is such an absorbing vocation. There are always problems. Each case of pneumonia, for example, differs from the next and requires much thought before a satisfactory course of treatment is outlined. It is the antithesis of the machine, absolutely unstereotyped, and demands continued intellectual exercise and individual adjustment. It should appeal to those who like independence of action and can bear the heavy responsibility that such action entails. And it should appeal to those who have curiosity—for to enter the Profession of Medicine is to enter upon an education that is never finished. One continues to learn until the last patient is seen or the last experiment finished.

The foundations for this individual variation which makes medicine so interesting rest upon variations in structure and in function. These matters of structure and function have received the most profound attention. The study of the structure of the body we call *anatomy*, the study of the function of the various parts of the body we call *physiology*. Certain individuals have elected to spend their time in the laboratories exploring these realms of science and have in turn added greatly to our ability to understand disease and how to treat it. Their studies of individual variations give us some hint at the reasons for the great variations in the picture of the same disease in different individuals. Those who elected to study structure soon explored not only the coarser but the microscopical structure of the body—*histology*. Having ascertained most of these facts they have turned in recent years to a careful investigation of the development that occurs in the growth of an organism from its first beginnings. This latter branch of medicine we call *embryology*, and studies in this field have thrown much light upon that great group of disorders roughly classified as congenital abnormalities, such as a split lip, the absence of fingers, the occurrence of hernia or rupture and the absence of certain bones or viscera. In order to appreciate better the development and use of certain structures, a few workers in this field have devoted much of their time to the study of the development of allied mammals, and the sciences of comparative anatomy and anthropology have become the workshop of the mediciner.

In the study of the function of the various organs and parts of the body—physiology—medicine has learned a vast amount of the greatest practical value. Imagine a doctor without a knowledge of the function of the circulation of the blood, the function of the lungs or of the digestive tract! This field has always drawn a large share of the brilliant minds in medicine. Laboratory workers in this field give annually to the practitioners facts of the greatest importance in both the diagnosis and treatment of disease. A whole lifetime devoted today to the function of the circulations, under the circumstances imposed by disease, would be of the greatest practical value.

Certain studies of function led directly into *chemistry*. Thus the ultimate study of the intestinal juices revealed the fact that, in the digestion of food, intricate chemical reactions take place which might well be interrupted in disease. We might use as an example the fact that normal digestion in the stomach only occurs if the reaction of the juices is acid; the reverse is present in the small intestines. Again, we find that the exercise of a muscle leads to the local production of acidity. All such problems need investigation if we are to care wisely for our sick. And workers in this field require special

training. Hence, the subdivision of physiological chemistry has arisen among the medical sciences.

Also in this field of function lies the science of *pharmacology*—literally, the knowledge of preparing medicines—actually, the study of the effects of drugs. This was an early subdivision of medicine in the day when "opposites" was the rule. Thus, diarrhoea was treated by a medicine to stop up the bowels, quite unconscious of the obvious deduction which might be drawn that diarrhoea resulted from an effort on the part of the body to get rid of an obnoxious matter and that, therefore, the logical treatment should be castor oil. Thanks to this science, we use fewer drugs but know more about them.

Finally and perhaps foremost of the sciences upon which the great structure of medicine rests is the science of pathology. Pathology literally translated has practically the same meaning as medicine, that is—that science dealing with the form, structure and symptoms of disease. In a practical sense it means the study of diseased tissue. It constitutes, with anatomy and physiology, the tripos upon which medicine rests. To some extent bacteriology is merely one of its subdivisions. It was a favorite field for study long before bacteria were recognized as a cause of disease. Examination after death reveals alterations in organs which are the results of the disease. A study of such alternations in many cases may well reveal all the states of the disease and thereby stimulate ideas as to possible treatment or prophylaxis or indeed give rise to further experimental study before the answer is at hand. The workers in this field have the closest contact with the practitioners; it is they who perform autopsies and examine specimens removed at operation. As has been often said, "in the dead-house lie the facts." One may hear many wonderful sounds with a stethoscope—that instrument with which a doctor listens to the heart and lungs, and often uses to amuse or terrify his youthful patients—sounds for which examination after death reveals no possible source. If one has ever had in one's hand the lung from a patient dead from tuberculosis and seen the cavities with small arteries strung across these cavities like telegraph wires, one can better understand the sounds that might be made by air entering and leaving such a cavity; and one can easily appreciate the source of the blood that such patients frequently spit up. Facts of this nature can not be learned from books nor lectures. Experience is the best master, and where it becomes a question of being entrusted with life in the future, none but the best masters should be consulted.

So much for a picture of the fundamental sciences upon which rests the profession of medicine. I have discussed them in some detail because it would be wrong for me to leave behind with you only that side that has to do with *practice*. As college graduates you should want the complete picture and should recognize the value of all the component parts of the profession. Indeed, I hope there are some who may find the laboratory field, with its freedom for uninterrupted hours of investigation and its lack of personal responsibility, the more attractive.

Medicine is both an *art* and a *science*. In the minds of the laity it is sharply demarcated into those who practice and those who do not. The laity speak of the incumbents of these separate fields as practitioners on the one hand and as *laboratory workers* or *scientists* on the other. It is commonly thought that the practitioner is a large-hearted, level-headed, overworked individual with much common sense, of great practical value, whose opinion on almost all matters except those dealing with financial affairs is to be desired, trusted and followed. On the other hand, it is commonly held that the laboratory workers are quite different creatures, who have peculiar tastes, are visionary and impractical and whose opinion, therefore, is rarely asked except where the matter concerns his very special field. No one seems to know just what he does, why he does it or what it all means. They are merely tolerated and frequently thought to be queer folk! And yet what I have just related to you regarding the laboratory sciences must have proved to you how wrong this attitude is, and indeed I hope it has opened your eyes to the fact that it is the workers of this type who usually give the most far-reaching and important additions to our special knowledge.

This may serve to depict the gross and commonly conceived divisions of medicine. It is indeed peculiar that a profession so widely esteemed and so ancient, for it antedates in so far as schools go all professions except pedagogy, should be so little understood. In the first place the *art or practice* and the science or *accumulation of knowledge* of medicine can not be separated. Any practitioner may, and every practitioner should, seek to add to medical knowledge. The science of medicine can be learned at the bedside as well as in the laboratory. Many facts indeed can only be determined at the bedside, and accurate observation made there, if correlated and studied, may yield important facts. Moreover, observations made at the bedside are a great source for laboratory investigation. It is often the questions raised at the bedside that result in the most brilliant and useful form of laboratory investigations. Thus, not only must the practitioner have a scientific attitude, but the medical scientist must have some knowledge of the practice of medicine and preferably some

contact, perhaps in a hospital, with sick individuals. The sick patient becomes the source of inspiration.

Indeed, there are certain limitations imposed on purely laboratory workers. Take, as an example, the study of *pain* in relation to disease. The general sum of medical knowledge, that is science, must derive its information in this field in a large part from bedside studies and the correct observation of the type of pain in certain disorders. To be sure in the laboratory we cut sensory nerves, study the degeneration of the nerve tracts under the microscope, and thereby accurately determine the course of the nerve fibers which carry the stimuli back into the central nervous system where these stimuli are recognized as pain. But recall for a moment the limitations imposed by other animal investigations. The chief objection is that even if simple experimentally created conditions should give rise to pain the laboratory worker has no means of recognizing it. He is defeated because pain is a complex symptom which needs language for expression. The laboratory worker can not talk to an animal. Moreover, in spite of what may be said by those narrow people who call themselves antivivisectionists, no reputable worker would willingly perform experiments causing pain or with pain as the object if only because his intelligence would point out to him in advance the uselessness of such work. To these men it seems pitiful that there exist individuals who can not and will not see the larger purpose of animal investigations. Are the thousands of children's lives saved through the experimentation that resulted in the production of diphtheria antitoxin worth the sacrifice of a few animals, particularly when one considers that this addition to medical science, once ascertained, will continue indefinitely as a blessing to the succeeding generation of men?

I hope what has been said will make it clear to all of you that medicine is both an art and a science, but that it can not be divided into two or three or four classes, that any one who becomes a member of this profession may play a dominant rôle in its advancement, and that it is indeed a mistake to enter this profession with the idea that by going into practice one has no responsibility or opportunity to enlarge the limits of medicine or that by going into a laboratory one should or can cease to have any interest in the clinical aspect or practice of the profession.

In the *practice of medicine* there are even more numerous fields open to the man interested in laboratory work. Primarily he must choose between general medicine and the specialties. This choice will be based on many issues. The place in which an individual desires to locate may be the dominant issue; if it is small he should, unless there are special reasons, accept the rôle of the general practitioner. It may be his choice will depend upon financial matters, for to become a specialist means postgraduate study—certainly a period of internship in a hospital, and usually two to five years more of intensive study in his chosen field. Or it may be that his choice is dependent on the inspiration of some special teacher who has by his way of living, his success and his teaching, stimulated a desire for a similar life.

Few, I imagine, determine their "walk of life" on an analysis of what field they are best suited for. The reward even in medicine plays a prominent rôle. It is difficult to speak with finality concerning the rewards of practice. Indeed, it is difficult to measure the real rewards and to place them in words. Financially, the specialties, whether medical or surgical, yield more return than the general practice of medicine; but a successful practitioner of medicine, no matter what his field or specialty, will derive a satisfactory income.

Personally I feel this is a most unwise and foolish method of electing one's life work. The critical point in the choice of a career is the selection of work in which one will be happy. Joy in work is the surest road to success. In the selection of a career in the practice of medicine, this should be kept in mind. Those men who will do best in the field of general medicine are those with a broad, patient, sympathetic and philosophical outlook, who like people, who make contacts easily and who shoulder responsibility well. There is no career demanding finer attributes, nor one which will put those attributes to the test so severely. As a rule those men going into surgery are less patient and philosophical, who get pleasure from action, who are more finite, and like to see for themselves. They want to know whether they are right or wrong and they often get into the rut of "seeing is the only way of believing."

But I do not think that any presentation of the possible rewards or suitableness of one individual or another will help you in your choice. Your choice of medicine will be based on some larger vision of the whole. This is why I have emphasized the fundamentals in discussing medicine as a career. The real reward in medicine is not in dollars and cents. The ethics of the profession of medicine preclude a large financial reward, that is, large in comparison with business. Medicine does not need nor want in its ranks those who are activated by such motives. The chief rewards in the practice of medicine come to the individual doctor through the, often unspoken, devotion of his patients, through the sense of a task done to the best of his ability and through the knowledge that each day is sure to bring its interesting problems.

Perhaps the most lasting reward is the sense he has of the faith of the people in his profession. This faith in doctors is a wonderful heritage, patients will

tell secrets and problems of their lives to doctors which their families and clergy never hear—even to a new and strange doctor. It bespeaks long years of correct dealing, fine ideals and good service. This faith of the people is the one thing that keeps the profession of medicine as a whole at a high level. Doctors are no different from other folk, but their form of service, their work and the faith of people in them are calculated to bring out the best there is in them. There is something about suffering that strikes home at the best fibers. It is something that makes one glad to miss a night's sleep or a friend's dinner.

But pictures of rewards are not what should be shown to those electing a career. What you should see is the various phases of the work, so that what may interest you may be selected. Medicine needs no proselyting. It is a profession that deals with life, other than which man has no greater interest. It is rather that men should be discouraged from entering this field unless they profess a great interest and like work.

Those who contemplate entering medicine should have some preliminary scientific training. Unfortunately the major part of our early education is chiefly a practice in memory, that is, languages, history, geography, etc. Logic is of much assistance, but mathematics are scarcely as well drilled into students now as they used to be. And there is almost no training in the scientific method of accurate observation, the correlation of facts, the drawing of deductions from facts and the synthesis of facts. One of the greatest difficulties in first-year medical students is to teach them the value of a correct observation. It is true that chemistry and physics are gradually creeping into precollege curricula. But should we stop there? Why not actually teach students some of the facts of life and sacrifice a little syntax? Even if they never heard of medical schools, they might all be wiser, healthier and happier citizens for it.

May I again in closing ask you to consider your own qualifications before you reach any decision as to your choice of a career? Remember that it is extremely difficult to change one's field of work in the future. In medicine you can choose a very varied career; those of you with great curiosity, a wide vision and some ingenuity will doubtless be happier in some laboratory field; the more patient and philosophical will enter that most honorable career of a general practitioner; the less patient may become specialists.

The final choice must rest with one's interest—that interest can only be determined by actual contact. As regards an opportunity to advance the science of medicine and leave a lasting contribution for the good of mankind, all branches hold an equal opportunity. But no two students receive the same reaction. In one sense pathology and obstetrics are at opposite ends of the medical spectrum. Thus, pathology deals with the dead or critically ill and to a large degree deals with people on the downward trend of life, whereas obstetrics deals with the beginning of life, with young people and a period of life when there is usually much rejoicing. People reflect their lives. Pathologists are rarely boisterous folk, obstetricians are proverbially jovial and stout. Pathologists on the other hand have done a great deal more to advance our knowledge of disease. To some this difference of surroundings may be a matter of importance. You must see these different fields yourselves in order to choose wisely.

> The doctor has always been somewhat cloistered from the world of affairs. Untrained in executive and business matters, and traditionally unsuccessful in these as a rule, he has been separated by his unsuitable training and by the urgent character of his work from any active part in public affairs. Indeed, he has been excused by law from some public duties that other men are obliged to do, and by common tradition has been free of criticism if he took less part in other such matters than do most men. Medicine has in fact attracted very largely men who temperamentally shun public activities. Besides this, one of the more or less definitely recognized large compensations in medicine, and one that has been jealously guarded and perpetuated, is that the doctor owes obedience to the law and to his own conscience, and is not subject to human masters.[2]

This sense of freedom from control with its obvious assumption of great individual responsibility may be a determining factor in the final choice of a few individuals. It may be that this constitutes one of the greatest differences between business affairs and the profession of medicine.

ELLIOTT C. CUTLER

WESTERN RESERVE MEDICAL SCHOOL

AN OBJECTIVE DEMONSTRATION OF THE SHAPE OF CELLS IN MASSES[1]

IF the cells of plants or animals, whenever they are grouped in masses, are typically fourteen-sided bodies of a particular pattern, ought not that fact to find a place in every elementary presentation of structural

[2] Edsall, D. S., "Movements in Medicine." *Boston Med. & Surg. Jour.*, 1916, CLXXIV, 891–892.

[1] This review, written at the request of the editor, is a partial synopsis of two papers obtainable from the American Academy of Arts and Sciences, Boston: "The Typical Shape of Polyhedral Cells in Vegetable Parenchyma and the Restoration of that Shape following Cell Division" (Proc., Vol. 58, No. 15, 1923); "A Further Study of the Polyhedral Shapes of Cells: I. The Stel-

botany or zoology? Even before the cell theory had been established—when cells were of less significance than at present—Kieser thought what a fine discovery it would be if some three-dimensional shape could be assigned to them, which would account for their prevailing hexagonal form in sections. There are two reasons for the present lack of interest in the problem.

First, it was recognized that free cells take the form which has a minimal surface for its mass, and are spherical; and Kieser, in 1815, announced that cells, when pressed together, preserve a minimal surface in so far as conditions allow. This has been universally accepted, and many think that if the determining physical factor is known, what matters the particular shape assumed in various cases?

The second reason for evading so fundamental a question has been the assumed incompatibility between the irregularity of actual cells and the precision of the interpretive diagrams. After studying Brisseau-Mirbel's figures, Kieser declared that cells in masses are either rhombic dodecahedra (which have twelve quadrilateral facets) or more usually are truncated rhombic dodecahedra, with eight quadrilateral and four hexagonal facets. This conclusion, accepted at first, gradually disappeared from the books, not because it was disproven, but because it seemed too schematic and artificial. Its latest advocate is perhaps Sir D'Arcy Thompson, in "Growth and Form," who makes the guarded statement that "very probably" the rhombic dodecahedral configuration is "generally assumed." Schaper, apparently unaware of the earlier literature, thought that massed cells are *regular* dodecahedra, with twelve pentagonal facets. These have less surface than rhombic dodecahedra, but they can not be stacked, so that Kieser considered them eliminated, and Schaper must have assumed that actual cells are nothing better than malformed approximations of that shape. Von Mohl's safe verdict was, "Better than *dodecahedral* is the designation *polyhedral*."

Meanwhile Lord Kelvin had found that a fourteen-sided figure—a cube truncated by an octahedron—having six quadrilateral and eight hexagonal surfaces, solves the problem of dividing space without interstices into uniform bodies of minimal surface. If the surface area of a sphere is taken as a unit, the non-stackable pentagonal dodecahedron of the same volume has a surface area of 1.0984, the orthic tetrakaidecahedron's surface is 1.0987, and that of the rhombic dodecahedron is 1.1050.

late Cells of *Juncus effusus;* II. Cells of Human Adipose Tissue; III. Stratified Cells of Human Oral Epithelium'' (Proc., Vol. 61, No. 1, 1925). An extensive group of sections and models of these cells was demonstrated at the recent meeting of the anatomists, in New Haven.

The studies at the Harvard Medical School include the counting of the surfaces of two hundred cells. The cells are indeed irregular, and the number of surfaces per cell varied from six to twenty, but the average number was 13.97. Altogether seventy cells were reconstructed in wax, so that their volumes and surface areas could be measured, and the shape of their facets studied in detail. Nothing suggestive of the rhombic dodecahedron was found, but in a number of instances the typical alternation of quadrilaterals and hexagons, characteristic of the tetrakaidecahedron, was strikingly exhibited. Further, it was determined by Professor Graustein—to whom, and to Professor Davis, I am indebted for the entire mathematical part of the work—that there is no transition between the twelve-sided and fourteen-sided forms. It is impossible by any maneuvering, as it were, to insinuate two additional surfaces and change dodecahedra into tetrakaidecahedra. The arrangements of spheres to produce these two forms differ at the outset. Spheres which make dodecahedra are stacked like cannon balls, which is the "normal piling" of engineers. For tetrakaidecahedra the spheres can not be so closely packed. In certain planes they stand apart from each other by .31 of their radius, and so avoid a deformation which would increase their surface area by only fifty-eight one-hundredths of one per cent. If so slight a difference in area controls the shaping of cells, surface tension is a factor of unexpected potency.

The cells studied include those of elder pith and human fat. The former are produced by division of pre-existing cells. A mass of tetrakaidecahedra, arranged with hexagonal surfaces above and below, has the surprising property of retaining the fourteen-hedral form if every cell divides horizontally and constricts at the plane of division. Division in a vertical plane destroys the pattern and necessitates a complex readjustment for its restoration. Elder cells show a great variety of modifications of the typical pattern due to cell division.

Fat cells enlarge after they have ceased to multiply, and assume forms quite like those of elder pith, except that they are not oriented in relation to an axis. In both cases pentagonal surfaces are frequently substituted for alternating quadrilaterals and hexagons, with a resulting diminution of surface area, as determined by measuring the models. Through irregularity, cells have advantages greater than that of the geometrical type from which they deviate.

A very attractive and highly exceptional form of cell is found in the pith of Juncus. Each cell is typically a star with six bifid rays, so that it has twelve contacts with other cells. But it is derived from a fourteen-sided parenchymal cell, which regularly loses two of its contacts, namely, those with the cells im-

mediately above and below. A curious result is that the intercellular spaces become themselves tetrakaidecahedral enclosures, bounded by the arms of eight surrounding cells.

The smaller cells of stratified epithelium were modeled to a limited extent. They also are primarily tetrakaidecahedral, and sustain the conclusion that this is the typical form whenever cells occur in masses.

What further studies are suggested by these observations? Since the modeling of vegetable cells is relatively easy, an extension of this research to other tissues of plants is entirely practicable and promises interesting results. But instead of undertaking this at present in the Harvard laboratory, we are considering the eight-surfaced cells of the simple epithelium of animals. When this epithelium is spread in a flat sheet, its cells are commonly hexagonal prisms with flat or more or less rounded ends. But when such an epithelium forms the wall of a cylindrical tube or duct, its cells necessarily become compressed at their inner ends and somewhat expanded basally—more so when they line a spherical alveolus. Professor Graustein is calculating the changes in surface area that accompany these three arrangements, and this is apparently a new problem. The appearance of the cells in sections suggests that surface tension may cause the narrowed ends to tend to withdraw from the lumen, leading to the production of basal or parietal cells; and it may be that the terminal bars or "Schlussleisten" serve to counteract this effect by holding the narrow ends in position.

The problem of the endothelial cell also is seen in a new light, if attention is given to the shape of the cells. They are remarkable departures from the spherical form which free cells tend to assume, and the cause of their flattening has not yet been determined. If a capillary wall consists of active protoplasmic cells flattened because of tension, it is quite possible that the capillaries possess a tireless contractile force apart from any Rouget's or muscle cells. This also is under investigation; and the two problems here outlined may suggest still other applications of the conclusion that cells in masses are typically tetrakaidecahedral.

FREDERIC T. LEWIS

HARVARD MEDICAL SCHOOL

WILLIAM OTIS CROSBY

IN the early dawn of December thirty-first, as the year 1925 drew to its end, the spirit of William Otis Crosby returned to Him who gave it. Thus ended a life spanning three quarters of a century and a geological career of more than fifty years.

It was in the little village of Decatur, Ohio, that Crosby was born on the fourteenth of January, 1850. He came o. all-English stock, and his ancestors settled in eastern Massachusetts shortly after the landing of the Pilgrims. From Ohio Crosby's parents moved to Toledo, Iowa, when the child was five years old. Later came the Civil War, and a boy of eleven watched his father march away to defend the Union, leaving heavy responsibilities upon very small shoulders; for three younger children now looked to him for help the father could no longer give.

Peace restored, the father became superintendent of a gold mine in North Carolina and soon brought his family to the new field of labor. Here in the Carolina hills the eyes of young Crosby opened to the wonders of nature, and he began to read such books on geology as he could secure. A clerkship in the Pension Bureau at Washington took the boy for two years into a less romantic atmosphere; but the evenings were his own, and geological literature was here more accessible. It is not surprising, therefore, that when in the early spring of 1871 young Crosby journeyed westward with his father, it was with a mind keenly alert to the geological features passed on the way. A carefully kept journal records not only his interest in the herds of wild buffalo seen on the plains and his enthusiasm for the vision of snow-clad Rockies looming on the western horizon, but likewise a host of geological observations which show that the youth of twenty-one had also scientifically "come of age."

During the summer Crosby twice ascended Gray's Peak, the last time in company with a party from the Massachusetts Institute of Technology, which included President Runkle, four professors and twenty students. Before the party left Crosby had made up his mind to enter the institute that same fall. Leaving the assay office in Georgetown where he had found employment, he journeyed eastward in November, quickly made up lost work and carried through his program of studies, although not without an interruption of one year spent with his father in a silver mill near Georgetown. It was to the Colorado home also that he returned for most of the summers during his years as an undergraduate at the institute. But the summer of 1873 found him a student of the great Agassiz in the summer school at Penikese, an experience which made a deep impression upon the maturing young scientist.

On his graduation from the institute in 1876, Crosby obtained a position as assistant in geology and mineralogy in the Boston Society of Natural History, where he served under the distinguished paleontologist, Alpheus Hyatt. At the same time he was made assistant in geology at the Massachusetts Institute of Technology, where he became instructor two years later, soon rising to professorial rank, which position he held until 1907, when increasing deafness caused

his retirement. From 1878 until his death, his home was in Jamaica Plain, one of the suburbs of Boston.

Professor Crosby's career as a geologist is remarkable not only for his productivity, apparent from the list of his published books and articles, numbering more than one hundred titles in addition to more than two hundred brief reviews and abstracts, but also for the diversity of geological phenomena which claimed his attention. Every page of nature's book which opened before him held something to excite his inquiring mind. The westward journey in 1871 and a camping trip with his father in the Rockies gave material for his first papers, published in the *Scientific American* when he was twenty-two years old. A three-months' camping trip on Trinidad in 1878 and a trip to Cuba three years later were productive of eight papers dealing with a variety of geological features in those islands. Two text-books on minerals and rocks which have passed through several editions and are still in use, although written forty and forty-five years ago; a book and many papers on dynamical and structural geology; five papers on the origin of joints, a dozen on water supply problems and numerous articles on chemical geology, ore deposits, petrography, pegmatite veins, soils, elevated beaches and various problems in glacial geology; these indicate, although they do not measure, the scope of his geological interests. Nor do they include his highly important contributions to the areal geology of eastern Massachusetts, of which his three volumes on the geology of the Boston Basin are notable for their able treatment of a very complex region. The Boston Basin study was projected as his *magnum opus,* the three volumes in question being but parts of a great work intended to occupy eight volumes.

In the engineering profession Professor Crosby's advice as a consulting expert was highly valued, and his name is thus linked with important engineering projects in the United States, Alaska, Mexico and Spain, including the Catskill Aqueduct, the Muscle Shoals Dam, the Arrow Rock Dam, La Boquilla Dam (Mexico) and other enterprises of the first magnitude. In the mining world he was frequently called upon to solve problems relating to the origin and structure of ore deposits; and in the courts his testimony was commanded as an aid toward the solution of legal controversies involving geological principles.

It was as the man and teacher that the present writer knew best the subject of this sketch. Frequent passages through New York City made Professor Crosby a welcome visitor at Columbia University, where a little group of graduate students found in him a man who combined genial humor with an unaffected interest in their personal and professional plans. When one of these students was called to the Massachusetts Institute of Technology to begin his teaching career under Professor Crosby's leadership, he had opportunity to know at its best a sympathetic nature which shrank from inflicting pain on any living creature, and which was the logical fruition of the youth who in 1873 contributed to the *American Naturalist* a touching "Instance of Affection and Sagacity in a Dog." With Professor Crosby vegetarianism was not a fad, but a principle.

As a teacher Professor Crosby counted among his students a host of engineers and a goodly number of men who chose some form of geological work as a profession. These will long remember his class-room instruction enriched by a wide acquaintance with geological phenomena in different parts of the world, and his field excursions to many parts of a local area unusually rich in geological problems.

In 1876, Professor Crosby married Alice Ballard, and she and one son, Irving B. Crosby, survive him. For them and for all others who knew Professor Crosby intimately, one memory will always stand out clearly among the many which cluster about his name: the memory of a spirit which remained patient and cheerful while increasing deafness deepened the silence in which he passed the later years of his life. Happily his eyes were undimmed, and from his summer home in New Hampshire he enjoyed, as could few others, the majestic panorama of the Presidential Range. It is fitting that his ashes should return to the New England soil so early trod by his ancestors, and that his name should be carved on a slab of the rock to the study of which he gave much of his life.

Douglas Johnson

Columbia University

SCIENTIFIC EVENTS

THE NATIONAL PHYSICAL LABORATORY OF GREAT BRITAIN

The report for the year 1925 of the National Physical Laboratory, just issued, states, according to the report in the London *Times,* that a good deal of research work has been accomplished besides the fundamental work involved in the maintenance of standards of measurement and of quality and performance. It is stated that experiments have been started with a view to finding a suitable method for making absolute measurements of sound intensity. With regard to the primary line standards, the report states that the present limit of accuracy attainable in comparisons must be taken to be about one hundred-thousandths of an inch. In this relation it adds: "A new four-meter standard bar has recently been obtained for work in connection with the verification of surveying tapes. Intercomparison of this with the previous four-meter

standard and two one-meter standards, the comparisons forming a closed series, has given results for the four-meter bars with a probable error of one part in five millions. The length obtained for the old four-meter bar shows that it continues to grow at the rate previously anticipated."

It is reported that the section of the laboratory dealing with barometers has been assisting the Air Ministry and the British Engineering Standards Association in establishing a basis for the graduation of aircraft altimeter aneroids, and that the construction of a new fundamental standard barometer is proceeding. With reference to the work of the physics department, the report says: "Considerable progress has been made with work bearing on the international temperature scale. Proposals for determining this scale will be laid before the Commission Internationale des Poids et Mesures in 1927; it will probably be a practical scale, approximating to the thermodynamic scale as closely as present knowledge will permit, based on a number of fixed points with definite methods of interpolation and extrapolation between and beyond these points."

Mention is made of research into the illumination of rooms by daylight and artificial light, and the effect of different kinds of illumination on the accuracy, speed and comfort of working. It is stated that tests have been made for the Office of Works to determine the minimum daylight factor satisfactory for clerical work. Also the lighting of the Raphael Cartoon Gallery at the Victoria and Albert Museum has been investigated with a view to securing the maximum illumination consistent with the elimination of those portions of the spectrum most likely to cause fading.

Dealing with the program of aeronautical research, the report says: "It is clear that valuable information is being obtained as to the nature of the air flow round an aeroplane and other structures which must in the long run, and probably at no very distant date, profoundly influence both theory and practice in aeronautics. The complications of aerodynamics as applied to the modern problems of flight are very great, and without the guidance that is provided by the study of the essential phenomena and the fundamental principles, the designer would indubitably continue to grope for many years through a tangle of disconnected and often apparently contradictory experimental data."

The report records the assistance given by the laboratory to firms and other bodies from whom inquiries and requests have been received. Frequent visits to the laboratory have been paid by representatives of these bodies and also by visitors from Dominion, Colonial and foreign institutions. An interesting report on the wireless work of the laboratory is included. This concerns an examination of signal strengths under a set of varying conditions. For this purpose a motor-car was equipped with receiving apparatus and in the course of tours extending from Bexhill in the south to Aberdeen in the north and Dartmoor in the west readings were taken about every 20 miles. The transmitting station at St. Assise, near Paris, was used, and one remarkable result of the observations was that signals taken in the vicinity of York were only about 15 per cent. of the intensity of those taken simultaneously at Aberdeen. Apparatus for the measurement of intensity of signals on short wave lengths is now under construction.

NEW FOREIGN MEMBERS OF THE ROYAL SOCIETY

THE Royal Society has elected eight foreign members, to fill vacancies, occasioned by deaths, since 1921. The names of the newly elected members with some details of their respective careers, as given in *Nature*, are as follows:

PROFESSOR MARTINUS WILLEM BEIJERINCK

Professor Beijerinck is regarded as the foremost bacterial physiologist of his time. He was the first to isolate in pure culture the bacteroids of the Papilionaceae and to study filter-passing viruses of plant. He began in 1884 an important series of memoirs, which were published by the Amsterdam Academy of Sciences. They dealt with photogenic bacteria, anaerobes and kindred subjects. Two of his papers may be cited: (1) "Die Bacterien der Papilionaceen-Knöllchen" (*Botanische Zeitung*, 1888), (2) "Les expériences sur les bactéries lumineuses" (*Journal de Micrographie*, 1891).

PROFESSOR NIELS BOHR

Born at Copenhagen in 1885, Professor Bohr received his academic training at the universities of Copenhagen, Cambridge and Manchester. At the last-named he spent four years working with Sir Ernest Rutherford. Returning to Copenhagen in 1917, he gathered round him a band of helpers in attacking the complex problem of atomic structure from the spectroscopic side. Author of the conception to which the name Bohr-atom has been attached, he has made fundamental advances in interpreting spectroscopic phenomena in terms of quantum dynamics. He was Hughes medallist of the Royal Society in 1921, and received the Nobel Prize for Physics in 1922. Professor Bohr delivered the seventh Guthrie lecture of the Physical Society, in 1922, on "The Effect of Electric and Magnetic Fields on Spectral Lines."

PROFESSOR ERNST COHEN

Born at Amsterdam in 1869, Professor Cohen was formerly occupant of the chair of physical chemistry in the university of that city. He is now professor of physical and general chemistry and director of the Van't Hoff

Laboratory in the University of Utrecht. He has published many chemical memoirs through the Amsterdam Academy of Sciences and in the *Zeitschrift für physikalische Chemie*. He is distinguished for his researches on the allotropic states of the chemical elements. As a pupil and follower of Van't Hoff, chemists owe much to him for methods by which sound foundations have been laid for physico-chemical theory. Professor Cohen recently was elected president of the International Union of Pure and Applied Chemistry.

Professor Willem Einthoven

Born at Semarang, Java, on May 21, 1860, and educated at Utrecht, Professor Einthoven has been, since 1886, professor of physiology in the University of Leyden. Early in his career he was an assistant of Donders. He is LL.D., Aberdeen, and in 1924 was the recipient of the Nobel Prize for Medicine. Professor Einthoven has devised instruments specially adapted to the study of physiology, as well as those suitable in high degree for physical researches. Important papers have illustrated and illuminated his procedure. One memoir of his may be cited, namely, "On the Theory of Lippmann's Capillary Electrometer" (1900).

Professor Karl E. Ritter von Goebel

Born at Billigheim, Baden, in 1855, von Goebel was educated at the universities of Tübingen, Würzburg and Strasbourg. He is a foreign member of the Linnean Society. Elected to the chair of botany at Strasbourg in 1881, he later occupied posts at Rostock and Marburg, down to the time when he became professor of botany at the university and director of the Royal Botanic Gardens, Munich. An authority on the mosses and liverworts (Bryophyta), some of his work has appeared in English under the title "The Organography of Plants" (Oxford, 1905). He is an honorary LL.D. of the University of St. Andrews.

Professor Henry Fairfield Osborn

Born at Fairfield, Connecticut, in 1857, Professor Osborn graduated at Princeton University, U. S. A., holding there (1880–91) the assistant professorship of comparative anatomy. Afterwards (1891–1910) he occupied the chair of zoology in Columbia University, New York, and is now research professor of zoology there. Professor Osborn is among the most distinguished paleontologists of our time. His first publication (1883) dealt with the structure of the brain in amphibia; later memoirs dealt mostly with fossil vertebrates. One of the results of his work is the more precise determination of the relative ages of the extinct mammals of North America. As director of the American Museum of Natural History, Professor Osborn has made the institution world-famous. He has had distinctive influence in establishing a school of younger paleontologists. In 1918 he was Darwin medallist of the Royal Society. In our recent special issue relating to the centenary of Huxley (May 9, 1925), Professor Osborn contributed an interesting article entitled "Enduring Recollections."

Professor Max Planck

Professor Max Planck was born at Kiel in 1858. Formerly a professor in the University of Kiel, he is now professor of mathematical physics and director of the Institute of Theoretical Physics in the University of Berlin. His outstanding achievement has been the foundation of the quantum theory—Planck's constant is now considered to be one of the fundamental constants in nature. Planck first discovered the true law of black body radiation; then showed how this could be satisfactorily explained in terms of a system of dynamics. From this the modern quantum theory has grown, with all its far-reaching developments.

Professor Arnold Sommerfeld

Professor Sommerfeld was born at Königsberg in 1868, and was educated there and at Göttingen. Formerly holding professorships at Claustal and Aachen, he is now professor of theoretical physics in the University of Munich. His book "Atomic Structure and Spectral Lines" (English edition) contains an account of mathematical work on the structure of the atom, his own contributions being of very high value.

THE WORLD FORESTRY CONGRESS

The World Forestry Congress meeting in Rome, from April 29 to May 5, formulated recommendations for the establishment of a Bureau of Forestry Statistics in the International Institute of Agriculture. It is proposed that the bureau shall be headed by a forest economist of recognized experience and ability, and that it shall cooperate with the statistical organizations in the different countries, with the object of getting fairly uniform, world-wide statistics on forest resources, production and trade.

Other resolutions urged public action to bring about increased production in privately owned forests; more attention to increasing production, in forest management plans; large increases in the area of public forests; official international action to insure regular supplies of reliable forest tree seed at reasonable prices; research in forestry genetics in all countries; more research in tropical forestry. It was recommended that all grazing lands be handled under systematic working plans, preferably by foresters, and that forest research stations study problems of range management and forage production. Regulation of grazing and of shifting cultivation and the control of burning in all tropical and sub-tropical countries were favored.

The next congress is to be called by the International Institute of Agriculture, probably in 1929 or 1930, and is expected to be held in some tropical country.

ACTIVITIES OF THE ROCKEFELLER FOUNDATION

DURING 1925 the Rockefeller Foundation spent $9,113,730 through its departmental agencies, the International Health Board, the China Medical Board, the Division of Medical Education and the Division of Studies, in the following activities:

(1) Aided the governments of eighteen countries to combat hookworm disease; (2) gave funds to the budgets of organized rural health services in 220 counties in twenty-six American states and in eighteen districts in Brazil, Poland, Czechoslovakia, Austria and France; (3) took precautionary measures against yellow fever in Salvador, Guatemala, Nicaragua and Honduras; (4) continued to work with Brazil in freeing its northern coast from this disease; (5) sent a yellow fever commission to the West Coast of Africa; (6) helped to show the possibilities of malaria control in twelve American states, and in Brazil, Argentina and Italy; (7) shared in the development of professional training of public health officers at Harvard University and the University of Toronto and in schools and institutes in London, Copenhagen, Prague, Warsaw, Belgrade, Zagreb, Budapest, Trinidad and Sao Paulo; (8) contributed to the progress of medical education at Cambridge, Edinburgh, Copenhagen, Brussels, Utrecht, Strasbourg, Beirut, Singapore, Bangkok, Sao Paulo and Montreal; (9) provided emergency aid in the form of literature and laboratory supplies for 112 medical centers in Europe; (10) maintained a modern medical school and teaching hospital in Peking with 164 students and fifty-five teachers; (11) aided two other medical schools and nineteen hospitals in China; (12) helped to improve the teaching of physics, chemistry and biology in three Chinese and seven foreign institutions in China and in the government university of Siam; (13) supported nurse training courses in Peking Union Medical College, Yale University, Vanderbilt University and the George Peabody College for Teachers, and contributed to nursing education and service in Brazil, France, Yugoslavia and Poland; (14) provided current funds for an Institute of Biological Research in The Johns Hopkins University; (15) assisted departments at Yale and Iowa State universities engaged in biological and mental research, and aided the Marine Biological Station at Pacific Grove, California; (16) provided, directly or indirectly, fellowships for 842 men and women from forty-four different countries, and financed the travel of fifty other persons either in commissions or as visiting officials and professors; (17) contributed to the League of Nations' international study tours or interchanges for 128 health officers from fifty-eight countries; (18) continued to aid the League's information service on communicable diseases; (19) made surveys of health conditions, medical education, nursing, biology and anthropology in thirty-five countries; (20) lent staff members as advisers and made minor gifts to many governments and institutions; (21) assisted mental hygiene projects both in the United States and Canada, demonstrations in dispensary development in New York City and other undertakings in public health, medical education and allied fields.

SCIENTIFIC NOTES AND NEWS

DR. HARVEY CUSHING, of the Harvard Medical School, was elected president of the American Surgical Association at the annual meeting in Detroit on May 26.

DR. WILLIAM T. HORNADAY, director emeritus of the New York Zoological Park, has been presented with a gold medal by the New York Zoological Society for his thirty years of "loyal, able and efficient service."

DR. SIMON FLEXNER, the director of the Rockefeller Institute for Medical Research, has been elected a member of the Royal Danish Scientific Society of Copenhagen.

DR. MICHAEL I. PUPIN, professor of electromechanics at Columbia University, retiring president of the American Association for the Advancement of Science and president of the American Institute of Electrical Engineers, was awarded the degree of doctor of science at the recent commencement of Rutgers University. The degree of LL.D. was conferred on Mr. Owen D. Young, chairman of the board of directors of the General Electric Company.

THE honorary degree of D.Litt. was conferred on Dr. Harvey Cushing, professor of surgery at Harvard University, at the annual commencement of Jefferson Medical College on June 4, when he gave the principal address.

DR. WILLIAM H. PARK, professor of bacteriology and hygiene at New York University, was awarded at the recent commencement of the university the degree of doctor of science.

THE degree of doctor of laws has been conferred by the University of Missouri on Hugh Lincoln Cooper, the hydraulic engineer of New York City, and on Jeremiah W. Sanborn, formerly dean of the Missouri College of Agriculture.

THE degree of doctor of science was conferred on June 7 by Franklin and Marshall College on Henry Kreitzer Benson, professor of industrial chemistry and chemical engineering at the University of Washington, Seattle.

AT a meeting of the Academy of Natural Sciences held on June 8 the following were elected correspondents: Henry Balfour, Erwin Baur, Joseph Grinnell, Michael F. Guyer, Fritz Hass, G. Carl Huber, Arthur F. Basset Hull, Chiyomatzu Ishikawa, Bunjiro Koto, Samuel O. Mast, Herbert Osborn, Carlos E. Porter, Norman D. Riley, Erwin F. Smith, Alexander Wetmore, August Weberbauer and Wilhelm Wenz.

DR. H. C. WILSON, for sixteen years director of Goodsell Observatory of Carleton College, Northfield, Minn., will retire at the close of the present year. He will spend a year in California, partly at the Mt. Wilson Observatory, after which he will return to Northfield to spend his time in research. To succeed Dr. Wilson, Professor E. A. Fath has been appointed director of Goodsell Observatory and Professor C. H. Gingrich and Professor E. A. Fath will assume the editorship of *Popular Astronomy.*

A FAREWELL dinner was given to Dr. J. E. Sweet, who has conducted the department of surgical research at the University of Pennsylvania for twenty years, by sixty of his friends on June 5, before he left to assume the chair of surgical research at Cornell University Medical School. Dr. George Dorrance presided and speeches were made by Drs. Wm. Pepper, Stewart, G. W. Norris, E. B. Krumbhaar, D. Guthrie, A. E. Richards and others.

THE board of council of the Milbank Memorial Fund tendered a dinner at the Hotel Biltmore, New York, in honor of Sir Arthur Newsholme, of London, previous to his sailing for home recently. Among the guests present were Dr. William H. Welch, the Johns Hopkins University; Dr. Hugh S. Cumming, Washington, D. C., and Dr. Livingston Farrand, Cornell University.

AT the end of the present session Professor A. G. Perkin, as has already been reported in SCIENCE, will retire from the chair of color chemistry and dyeing in the University of Leeds, severing thereby a connection with the university which has extended over thirty-four years. We learn from *Nature* that in view of Professor Perkin's long period of service and the valuable work which he has done in building up a school of research into color chemistry and the chemistry of natural coloring matters, work which is of great value to the textile and dye industries, a committee has been formed for the purpose of raising a fund which will enable the esteem in which Professor Perkin is held to be signalized, either by the presentation to the university of his portrait, or in some other suitable manner. Subscriptions are invited for this purpose, and should be sent to Professor A. F. Barker, The University, Leeds.

DR. C. RICHET, professor emeritus of physiology at the University of Paris, a pioneer in biology with anaphylaxis and serotherapy, was presented on May 22 with a bronze portrait bust and tributes from delegates of scientific societies throughout Europe. Belgium sent the insignia of the grand commander of the Order of Leopold, and General Foch presented him with the cross of the grand commander of the Legion of Honor.

THE Royal Society of Edinburgh has awarded the Keith Prize to Professor H. W. Turnbull, professor of mathematics in the University of St. Andrews, for his papers on hyper-algebra, invariant theory and algebraic geometry, published in the *Proceedings of the Royal Society of Edinburgh,* and the Neill Prize to Professor F. O. Bower, for his recent contributions to botanical knowledge, and in recognition of his published work extending over a period of forty-five years.

ON the occasion of his seventieth birthday, on May 6, the city of Vienna conferred honorary citizenship on Dr. S. Freud.

DR. KARL LANDSTEINER, a member of the Rockefeller Institute for Medical Research, has been awarded the annual prize of 1,500 marks of the Dr. Hans Aronson-Stiftung, Berlin, in recognition of his work on antigens and antibody formation.

THE Hubbard Medal of the National Geographical Society will be presented by President Coolidge to Commander Richard E. Byrd, on June 23. Floyd Bennett, who accompanied Commander Byrd on his polor airplane flight, will receive a gold medal.

DR. THOMAS STOCKHAM BAKER, president of the Carnegie Institute of Technology, is on his way to Europe to extend invitations to specialists to attend a conference in Pittsburgh next November to devise plans for extending the use of bituminous coal. The advisory board for the conference will be John Hays Hammond, Samuel Insull, Charles M. Schwab, E. A. Kerr, Dr. Frank Jewett and Otto H. Kahn.

ARTHUR C. VEATCH has been invited to Italy by Premier Mussolini for a conference on the oil situation and oil resources of Italy.

C. E. SKINNER has been appointed the delegate of the American Engineering Standards Committee to the International Conference on Standardization to be held in Europe this summer.

PROFESSOR HERMAN H. CHAPMAN has been granted a leave of absence from Yale University to participate in the government investigation on forest taxation, which is being conducted under the direction of Professor Fred R. Fairchild.

DONALD MATTHEWS, forester of the Tropical Plant Research Foundation of Washington, D. C., has left for Trinidad and other points in the Caribbean region to study problems of reforestation and rate of tree growth. Mr. William Crosby, associate forester of the foundation, is conducting similar studies in Porto Rico and Cuba.

DR. J. M. ALDRICH, curator of insects at the Smithsonian Institution, has left for Guatemala to make a collection of Central American flies which parasitize other injurious creatures.

CARLOS E. CHARDON, commissioner of agriculture and labor in the Government's Cabinet in Porto Rico, has been granted a three months' leave of absence and has gone to Colombia at the request of that government to organize a department of agriculture and establish an agricultural experiment station. Mr. Chardon is initiating a fungous survey of Colombia and plans to lead a mycological expedition into the interior of that country in the near future.

PROFESSOR JOHANNES WALTHER, of Halle, will be the guest of the geological department of the Johns Hopkins University, during the months of February and March of next year as visiting professor on the Speyer Foundation.

PROFESSOR KARL HERZFELD, of the University of Munich, will give a course of lectures on selected topics in kinetic theory during the summer session at the University of Michigan, from June 21 to August 13.

DR. WILLIAM E. WICKENDEN, of New York, director of research for the Society for the Promotion of Engineering Education, gave the commencement address at Lafayette College, on June 7.

DR. CHARLES P. BERKEY, of the department of geology, of Columbia University, recently gave a lecture at the University of North Carolina, at Princeton University and at Rutgers College, on the "Explorations of the Third Asiatic Expedition during 1925 in Central Asia."

DR. HEBER CURTIS, director of the Allegheny Observatory, addressed the Sigma Xi Alumni Association of the University of Pittsburgh at the last meeting. His topic was "The Astronomical Results and Problems of the Recent Solar Eclipse."

DR. GEORGE R. LYMAN, dean of the West Virginia College of Agriculture at Morgantown and previously pathologist in the Bureau of Plant Industry at Washington, D. C., died on June 7, aged fifty-five years.

PROFESSOR SAMUEL HOMER WOODBRIDGE, president of the Sanitary Engineering Company and for many years lecturer on heating and ventilation at the Massachusetts Institute of Technology, died on June 7.

DR. CHARLES B. DUNLAP, for twenty-four years chief assistant in the New York Psychiatric Institute on Ward's Island, died on June 7 at the age of sixty-four years.

THE death is announced, at the age of sixty years, of Benjamin E. Carter, associate professor of mathematics at Colby College.

DR. H. B. GUPPY, F.R.S., distinguished for his work on plant dispersion and coral-reef formation in the Pacific, died on April 23 at the age of seventy-one years.

SIR FREDERICK MOTT, the well-known British neurologist, died in Birmingham on June 8 at the age of seventy-two years.

THE Upsilon Chapter of the Phi Sigma Biological Society was installed in Miami University, Oxford, Ohio, on May 7, Dr. H. J. Van Cleave, of the department of zoology, University of Illinois, acting as installing officer on behalf of the council. Phi Chapter was installed in the University of New Hampshire on May 21, by Dr. Carl L. Wilson, department of biology, Dartmouth College.

THE city of Wiesbaden has appropriated 100,000 marks for the erection and equipment and 50,000 marks annually for the support of an institute for scientific research in balneology and metabolism.

UNIVERSITY AND EDUCATIONAL NOTES

BY the will of Mrs. Ellen Mills Borne, Columbia University receives $300,000, on the death of her brother, to found a chair in medical and surgical research, in memory of her husband, John E. Borne.

GIFTS amounting to $450,000 were announced at the recent commencement of Vassar College.

LELAND RUSSELL VAN WERT, for the past six years a member of the faculty of the Harvard Engineering School, has been named assistant professor in metallurgy at the Carnegie Institute of Technology. The appointment is announced as a further step in the reorganization of the Department of Mining and Metallurgical Engineering, Professor James Aston, former metallurgical engineer with the A. M. Byers Company, having been placed in charge of the department several months ago subsequent to the death of Professor Fred Crabtree and the recent resignation of Professor F. F. McIntosh.

DR. HORACE S. UHLER has been appointed associate professor of physics in the Sheffield Scientific School of Yale University.

DR. OTTO LAPORTE, Ph.D. (Munich), who has been for the past two years at the Bureau of Standards,

as a fellow of the International Education Board, has accepted appointment as instructor in physics in the University of Michigan for the year 1926–27.

Dr. I. S. Falk has been promoted to the rank of associate professor in the department of hygiene and bacteriology of the University of Chicago.

DISCUSSION

AN OUTDOOR OPTICAL EXPERIMENT

Distant landscapes, even in the clearest weather, are seen through a blue "haze" which is doubtless due to light scattered by the molecules of air. This effect is unusually conspicuous and remarkably beautiful in the Grand Canyon and the adjacent country. During a conversation with friends at the observatory it occurred to the writer that this blue light should be partially polarized and should therefore show variations when observed through a Nicol prism. Observations made on a trip to the Canyon and the Painted Desert show that this effect is remarkably conspicuous. As the Nicol is rotated the blue haze is alternately intensified and very greatly diminished. In the position of the greatest extinction the details of the distant landscape become much more conspicuous, while the sky between them is greatly darkened. The color scheme is strikingly changed, distant objects appearing more nearly in their true colors, while the whole landscape takes on a singular appearance, much resembling that which is observed a few minutes before or after totality during a solar eclipse, when the light, coming from the sun's limb, is deficient in the blue rays.

This polarization effect is at a maximum 90° from the azimuth of the sun (as might be expected) and is inconspicuous under the sun or opposite it, unless the sun is high in the sky. Distant clouds show it, as well as distant mountains, and have the advantage of being available from all stations. They are usually brighter than the sky in all positions of the Nicol, but most conspicuous when it is set for maximum transmission. A small wisp of cloud observed over the Grand Canyon appeared, however, bright on a dark sky when observed with maximum extinction, and dark on a bright sky with maximum transmission. This cloud was probably low in the atmosphere, so that the unpolarized light reflected from it, when diminished to half by the interposition of the Nicol, was less than the principal polarized component of the light scattered by the air behind it, but greater than the component polarized in the perpendicular direction. With the unaided eye, this cloud was just discernible, mainly by its color.

In general, it appeared that all details visible with the polarizing device could also be seen, though more faintly, with the unaided eye; but in some cases, among distant clouds, the Nicol prism seemed to show more than could otherwise be seen. This use of a familiar optical appliance must have been suggested before—perhaps many times—but it appears to be little enough known to justify this note. The effect under favorable circumstances is conspicuous enough to be of interest to the least informed spectator. In intimating the true colors of distant objects, and in detecting faint clouds, it may be of some value to the serious observer, and it should be of use to teachers of optics as affording a simple and striking demonstration experiment.

Henry Norris Russell

Lowell Observatory

SEISMIC WAVE VELOCITY AND DENSITIES OF CRUSTAL MATERIALS

In "A Seismological Note" in the issue of Science for March 19, 1926, Dr. Perry Byerly draws the conclusion that "the increased velocity of seismic waves beneath the Pacific can not be cited as an evidence of greater density beneath oceans than beneath continents."

It is true that certain writers have been guilty of incomplete statement when they have cited the increase of velocity in question as a proof of increased density. For it is well known that in general an increase in velocity from medium to medium may be accompanied either by an increase in density or by a decrease in density, or indeed by no change in density at all.

But in the case under consideration we are not dealing with elastic media in general, but with the crustal materials of the earth. Nor are we dependent solely upon the general considerations of elastic theory, for we have at hand experimental data of unquestionable reliability on the properties of a considerable range of typical crustal materials. I wish to point out on the basis of these data that an increase of velocity of seismic waves traversing a given portion of the earth's crust is indeed rather good evidence of greater density in that portion.

Adams and Williamson have shown[1] *that if typical crustal materials be arranged in the order of increasing velocities of seismic waves they will then also be in the order of increasing densities.* The only considerable exceptions are the heavy iron minerals pallasite and siderite, which are probably important only at considerable depths. Omitting pallasite and siderite from the list, as we pass from granite to dunite an increase in velocity of the P-waves from 5.6 to 7.3 and

[1] L. H. Adams and E. D. Williamson, "The Composition of the Earth's Interior," Smithsonian Report for 1923, page 250.

of the S-waves from 3.1 to 4.1 kilometers per second is accompanied by an increase in density from 2.61 to 3.38 grams per cubic centimeter.

Thus we see that there is a considerable experimental basis for citing the increased velocity of seismic waves beneath the Pacific as evidence of greater density of crustal materials there than beneath the continents. The retarding effect of greater density is more than compensated by the greater proportional increase in elasticity, as Angenheister has pointed out.

It may be of interest to call attention to another case where an increase in velocity of transmission of elastic waves is associated with increasing density. At 0° C. and for a salinity of 35‰ the velocity of sound waves in sea water increases from 1,450 meters per second at the surface to 1,591 meters per second at a depth of 4,700 fathoms,[2] the density increasing from 1.02813 to 1.06649 grams per cubic centimeter. The velocity undergoes this considerable increase *in spite* of the density increase because the bulk modulus of the water increases from 2.16×10^{15} to 2.70×10^{10} dynes per square centimeter.

JERRY H. SERVICE

U. S. COAST AND GEODETIC SURVEY

FIELD TRIPS IN GEOLOGY

THE recent announcement concerning the establishment of a "summer school of geology and natural resources" by the Department of Geology, of Princeton University, and more especially of a "travelling course" to be given as a part of the work of this school, is of such general interest to all students of geology that an account of a very similar course given in 1924 by the department of geology of the Mississippi Agricultural and Mechanical College may be of interest also to readers of this journal. The points of similarity may be readily seen by a summary of the itinerary of the two tours.

The travelling course described in the Princeton announcement is to be offered in 1926, beginning July 1 and lasting seven weeks. The party, consisting of Professor Field and Professor Buddington and twenty students, will travel in a specially constructed sleeping, dining and lecture Pullman car. According to the itinerary, "the principal localities to be visited this year will be the Silurian Section at Niagara Falls; Mesabi Iron Ranges; Yellowstone National Park; Glacier National Park; Butte Copper Mines and Anaconda Smelter; Columbia River Basin and lava flows; Mt. Rainier; Crater Lake; Yosemite National Park; Los Angeles oil fields; Grand Canyon; Flagstaff volcanic fields; Petrified Forest, Arizona; Appalachian Coal Fields; Appalachian Province and the Coastal Plain Province." Truly a wonderful education in itself.

After an Appalachian field trip in 1922 in two Ford trucks and a more extended one in 1923, the department of geology of Mississippi A. and M. College conducted a Pacific field trip for eleven weeks in 1924 under the direction of the writer, travelling in three Dodge cars, two touring and one commercial body. Such mode of travel is far more fatiguing than in a Pullman car, but it is more flexible and permits of almost exclusive daylight travel. The itinerary was very similar to the proposed one of Princeton University, west of the Mississippi, but more detailed. The principal places visited were the Arkansas Bauxite mines; Eastland-Ranger oil fields; Carlsbad Cavern; Petrified Forest; Crater Mound; Walnut Canyon Cliff Dwellings; Flagstaff volcanic fields; Grand Canyon; Mohave Desert; San Bernardino Mountains; Los Angeles oil fields, and Rancho La Brea deposits; Catalina Island; Mariposa Grove; Yosemite; Placerville, Coloma, and Nacoma past and present gold mines; Crater Lake; Mt. Shasta; Columbia River gorge and Mt. Hood; Mt. Rainier; Vancouver; Columbia River lava flows; Coeur d'Alene mines; Anaconda and Butte mines; Yellowstone National Park; Great Salt Lake; Bingham copper mines; Dinosaur National Monument; and Joplin zinc mines.

It would be interesting also, perhaps, to compare the results of these two trips taken under such different modes of travel, so far as comparison is possible of tours under different leadership. And, speaking from experience, one would probably feel impelled to say that it takes a courageous heart to plan, besides the field work, three hours six days a week of lectures, conferences and quizzes.

W. C. MORSE

MISSISSIPPI AGRICULTURAL
AND MECHANICAL COLLEGE

SPECIAL CHARACTERS FOR THE TYPEWRITER

I WAS interested in the suggestion of Mr. Hulse for adding a few characters to the typewriter, as published in SCIENCE for March 26, and also in the proposal of "Ad Infinitum," as published on page 477 of the issue for May 7.

The wavy underscore is certainly a good suggestion, although it may not accomplish much more than can be done by the colored ribbon. In some cases a writer may find it convenient to make use of both devices, and in any case he may use the one which serves his purpose best. But instead of the pair of brackets as used by Mr. Hulse, it seems that one might get along with a single vertical line, adding the horizontal portion at top and bottom by hand.

It seems like a rather hopeless undertaking to meet

[2] N. H. Heck and Jerry H. Service, "Velocity of Sound in Seawater," U. S. Coast and Geodetic Survey Special Publication No. 108.

all the mathematician's requirements on the typewriter and still have a machine which is suitable for ordinary service. But possibly we might provide him with two machines which would provide nearly all the characters commonly used. Say one machine with forty-two typebars and single shift carrying the characters usually found on a keyboard and with perhaps six special characters; another machine of the same size and make would carry the alphabet in twenty-six special capital letters, ten large numerals and ten small numerals for exponents and subscripts and arranged so as to be available for fractions, thirty-eight of the more commonly used mathematical characters. Manuscript would go through machine number one first, leaving blank spaces for such expressions as had to be filled in on the other machine. Finally the sheet would be put through the second machine in much the same way that a printed paper of any kind is now filled in on a typewriter.

By striking twice in a single space and by turning the roll as required, it is possible to produce a considerable number of special characters from the standard keyboard:

$$\underline{\overline{1}} \quad \overline{\underline{N}} \quad \cancel{Z} \quad \ominus \quad \not c \quad \emptyset \quad \not - \quad \angle \quad \underline{o} \quad \ne\!\!\!\# \quad \mp \quad - \quad X \quad \div$$

A name for some of these may be derived from the components, as when we abbreviate *hyphen-one* to read *hyon*.

JNO. D. RIGGS

INDIANAPOLIS, INDIANA

RADIO INFORMATION

RECENTLY a friend of mine here listened in on a radio talk broadcast by the New Jersey Experiment Station on the subject of clovers. In this talk the speaker mentioned the excellence of foreign clovers as shown in the experiments conducted by the New Jersey station, and stated that it was quite all right for American farmers to use foreign seed. The speaker did not state at any time during his talk that the statements he was making were to be considered as applying to his particular state only and not to the country as a whole.

We find that in this state the foreign clovers are very susceptible to anthracnose and therefore undesirable for our use here, whereas our own varieties are not so susceptible, and in cases where selection has been made, highly resistant strains of American clovers have been developed. Our farmers, listening in on some other state broadcasting what would be true under their own conditions, would not know that such might not be true for some other locality.

The speaker, broadcasting over the radio, sometimes forgets that his words are being heard over a wide expanse of country. It seems to me that there should be emphasis placed by each experiment station broadcasting that their findings and recommendations are for their *own conditions only,* unless indeed they are bringing together the results of research from many stations, in which case it would be equally necessary to so state. What is information in one place becomes misinformation in another place, and too much emphasis can not be put upon the limitations that should accompany recommendations.

L. S. MAYER

AGRICULTURAL EXPERIMENT STATION,
KNOXVILLE, TENNESSEE

SCIENTIFIC BOOKS

The Technique of Tissue Culture "In Vitro." By T. S. P. STRANGEWAYS, lecturer in special pathology in the University of Cambridge. W. Heffer & Sons, Ltd., Cambridge, 1924, pp. 80.

As indicated in the title this little volume contains a description of the technique employed in the cultivation of tissues "in vitro." In every instance the method described is given in great detail, a step at a time, with numbered paragraphs. As a typical example of the directions given in this manual, a few paragraphs may be quoted from page 58 in which Professor Strangeways gives directions for the simple operation of transferring plasma from a thermos bottle to a capillary pipette.

(1) Open one of the Thermos flasks, and with a pair of forceps remove the container of the plasma tube from the flask by means of the string handle.
(2) Remove the cork of the container, and with a pair of sterile forceps carefully lift out the tube containing the plasma.
(3) With a pair of sterile forceps remove the cork from the plasma tube, and place it on a sterile surface.
(4) Take a sterile paraffined pipette (Section XXV), and draw into it about ½ cc of plasma without touching the side of the plasma tube.
(5) Place the pipette in a glass jar so that the end near the bulb rests on the roll plasticine (Section XI).
(6) Recork the plasma tube, using sterile forceps, and place it in its container.
(7) Recork the container and replace it in ice in the Thermos flask.
(8) Cork and cap the Thermos flask.

The technique for the cultivation of tissues "in vitro" is generally regarded, and rightfully so, as being difficult to acquire. A careful following of the specific directions in this book would seem to make it possible for any one to acquire proficiency in tissue culture methods, even though he had had no previous

experience in this field. The book has value and fills a distinct need. It deserves a wide distribution.

Tissue Culture in Relation to Growth and Differentiation. By T. S. P. STRANGEWAYS, lecturer in special pathology in the University of Cambridge. W. Heffer & Sons, Ltd., Cambridge, 1924, pp. 50.

IN this book of fifty pages is given a general survey of the results obtained by the author from certain experiments with the cultivation of tissues "in vitro," together with his interpretation of these results in relation to various biological problems, such as mitosis, differentiation, inflammation and repair, etc. A careful reading of this book has given me the impression that the material contained in it, although of value, will not have a general appeal either to workers in this field or to the average reader.

GEORGE A. BAITSELL
YALE UNIVERSITY

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A CATHODE RAY OSCILLOGRAPH FOR SEVERAL SIMULTANEOUS WAVES WITH STABILIZED LINEAR TIME AXIS

A LINEAR time axis[1] for cathode ray oscillograph is obtained by repeatedly charging a condenser through a saturated thermionic rectifier and discharging through a neon lamp when a critical voltage is reached. The period, controlled by condenser capacity and rectifier filament current, can be made approximately synchronous with any periodic phenomenon under study, so that the oscillograph shows a nearly stationary wave or curve plotted against time in rectangular coordinates. Although, under these conditions, the wave may shift, it can be inspected and has proved highly satisfactory for certain purposes, *e.g.*, the graphical demonstration of heart sounds.[2]

For the study of physical phenomena, as alternating currents and voltages, it is desirable to have the wave or curve absolutely stationary, and, furthermore, to obtain two or more such waves simultaneously for precise comparison of phase, amplitude, frequency and wave form. In certain cases a synchronous contactor may be employed to obtain precise synchronism of the condenser discharge with the phenomenon under study, thus stabilizing the time axis and making stationary the wave. We have found this method satisfactory, but limited in its application and involving unnecessary auxiliary equipment. The desired end, however, is simply and satisfactorily obtained by tickling the neon lamp with a small alternating electromotive force[3] of the same frequency, whether it be high or low, as the periodic phenomena being studied, thus synchronizing the discharge of the condenser, without affecting its uniform rate of charge. This gives an absolutely stationary wave which may be photographed, or copied precisely on tracing cloth or by binocular vision.

A number of curves are readily obtained simultaneously by a motor-driven switch making connection to the several sources in rapid succession, the curves all appearing continuous and simultaneous due to persistence of vision. We have obtained three or four simultaneous curves (all absolutely stationary) with complete satisfaction and believe six or more could be obtained if needed. It has proved a convenient way of comparing wave forms of transformer input and output, showing the amount of distortion and amplification under different conditions. Any shifting of the curves would lead to confusion.

FREDERICK BEDELL,
HERBERT J. REICH
DEPARTMENT OF PHYSICS,
CORNELL UNIVERSITY

[1] Austin Bailey, *Physical Review* (2), 25, p. 585, April, 1925.

[2] Apparatus for this purpose, developed by the Western Electric Company, was exhibited by Dr. H. Clyde Snook, 1925, at Kansas City meeting A. A. A. S. and was previously exhibited at Atlantic City meeting Am. Med. Assoc.

[3] This may be conveniently applied through a potentiometer in series with the lamp.

SPECIAL ARTICLES

THE ISOLATION OF A CRYSTALLINE PROTEIN WITH TUBERCULIN ACTIVITY[1]

BEGINNING with Koch in 1891, many attempts have been made to separate from tuberculin the principle responsible for eliciting a skin reaction in tuberculous subjects. The exact nature of this substance has been a riddle and while most opinions proclaim it to be protein in nature, there have been many dissenting voices. A series of experiments consecutively carried out in this laboratory, and appearing in the May issue of the *American Review of Tuberculosis*,[2] seem to prove more or less definitely that the substance is of protein nature.

Briefly, these experiments show that the substance responsible for the activity of tuberculin is com-

[1] From the Department of Pathology of the University of Chicago and the Otho S. A. Sprague Memorial Institute, aided by a grant to Dr. Esmond R. Long from the Medical Research Committee of the National Tuberculosis Association.

[2] The Chemical Composition of the Active Principle of Tuberculin. I–VII. E. R. Long and F. B. Seibert, *Amer. Rev. Tuberc.*, 1926, XIII, 393.

pletely precipitated by $(NH_4)_2SO_4$, and practically all other protein precipitants throw it out of solution to some extent. It does not dialyze, and, in fact, is always associated with protein, while it is absent when all protein is removed. Moreover, it is attacked and thereby loses its activity when treated with the enzymes, pepsin + HCl or trypsin + Na_2CO_3, which attack whole protein, while acid or alkali of corresponding strength, and erepsin or trypsin in neutral solution, do not materially reduce the activity. Chemically, it is shown that wherever the activity is lost, following enzyme treatment, there occurs also a corresponding reduction in whole protein, with an increase in proteose and residual nitrogen.

With the thesis that the active principle of tuberculin is protein in nature, as a basis, an attempt was made to learn if the specifically active protein could be isolated in very pure form and possibly be among the few known proteins which will crystallize. Large quantities of tuberculin prepared by Parke Davis Co. and the Mulford & Co. for the National Tuberculosis Association, and made upon the non-protein synthetic medium recommended by Dr. E. R. Long, were used, and from it all the protein was precipitated by complete saturation with $(NH_4)_2SO_4$. This precipitate proved to consist of a water soluble non-coagulable protein, a water soluble heat-coagulable protein, and a water insoluble protein, the first two of which contained most of the tuberculin activity.

The water soluble non-coagulable dialyzed fraction was treated by Hopkins' method for isolating crystalline ovalbumin, and burrs or bundles of crystalline needles appeared on three different occasions from three different lots of material. These crystals take the methylene blue stain, and when thoroughly washed with an $(NH_4)_2SO_4$ solution of appropriate concentration and redissolved in water, give the biuret, Millon's and Molisch tests. These washed needles also give a marked skin reaction in tuberculous guinea pigs and none in normals, *i.e.*, satisfy the requirements for the recognition of true tuberculin activity. The purest lot of crystals so far obtained, nevertheless, still contains a few small particles admixed with the needles, which may be amorphous, and attempts are being made to make a preparation entirely free of such particles. However, it is possible that these amorphous-appearing particles are the precursors of needles, or needles whose formation has been retarded, since, as with ovalbumin, the amorphous precipitate which appears immediately, transforms itself into needles on standing.

There has, therefore, been found in tuberculin a protein which can be crystallized. Moreover, this crystallized protein apparently is able to elicit a tuberculin skin reaction. The more detailed analyses and the quantitative potency of the protein will be reported in greater detail in the near future.

FLORENCE B. SEIBERT

PRELIMINARY NOTES ON THE STRUCTURE OF PLANT PROTOPLASM

IN a recent paper[1] on problems touching the Golgi apparatus, I was led to offer some rather rash suggestions as to the homologue of this element in plant cells, where thus far nothing certain is known concerning even the presence of Golgi material. A paper of some years ago by Nassonov had demonstrated the possibility of impregnating with osmic acid (Kolatchev's method for Golgi material) certain elements of plant cytoplasm. The question which I put to myself was therefore an apparently simple one. Were some of the materials impregnated by Nassonov equivalent to the Golgi apparatus of animal cells—thus bearing out one of my theoretical suggestions? With this as a point of departure, I have now under way an extensive study of the structural elements of plant cytoplasm as revealed particularly by the various methods of osmic acid impregnation now in common use by zoologists for demonstrating the Golgi apparatus. The results thus far achieved have been very unexpected, and since their publication will be delayed pending the possible solution of several debatable points, it seems worth while to make now a brief preliminary statement.

Thus far root-tips from Vicia, Pisum, Hyacinthus, Ricinus, kidney bean, pumpkin and barley have been examined after preparation by various modifications of the techniques of Kolatchev and Weigl. Positive results of some sort have been obtained in practically all cases, but the different forms vary considerably in the degree of success attained and exhaustive tests have been made thus far only on Vicia faba. Taken as a whole, my trials show that practically everything in the root-tip cells can be impregnated with osmic acid, save only the chromatic materials. Following, where applicable, the non-committal terminology of the Dangeards, the components demonstrated are as follows:

(1) *Spindle fibers* and cytoplasmic network—substantially as described by Nassonov.

(2) *Plastidome*—particularly in the meristem at the root-tip end but usually not in older cells where leucoplasts have become differentiated. These bodies blacken intensely in accord with Nassonov's original finding.

(3) *Spherome* (probably equivalent to the bodies so designated by the Dangeards)—in cells of all kinds and ages in all the species carefully examined. The spherosomes occur in large numbers throughout the cytoplasm, though never intruding on the vacuolar spaces. They

[1] *Anat. Rec.*, Vol. 32, 1926.

are particularly large and well developed in the root-cap cells and in developing cells of the vascular areas. They show no special features of distribution in mitosis. Each spherosome is disc-like, not spherical in shape. The body of the disc is yellowed somewhat but not blackened by osmic treatment. The rim of the disc is blackened intensely. Thus, when seen in plane view, the spherosomes appear essentially as black rings, while in profile view they appear as rods. It is these "rods" which apparently constitute the "inactive chondriome" of Guilliermond, the real morphology of which is here described for the first time.

(4) *Vacuome*—very finely demonstrated and particularly studied thus far only in Vicia faba. The general results are in remarkable agreement with the accounts heretofore given by the Dangeards using vital dyes. In my preparations, however, the vacuome is for the first time demonstrated in the finest detail and in a form adapted for permanent preservation and study. In the earliest meristem cells the vacuome consists of many roughly spherical masses scattered throughout the cytoplasm and blackened in a more or less complete way. Every step in the fusion of these vacuoles to form the large "cell-sap" areas of the plerome cells has been followed in detail. In the periblem cells, the history of the vacuoles is somewhat more complicated and is still being studied. In the periblem the networks early formed by fusion of the vacuoles often undergo a characteristic fragmentation during mitosis, reminiscent of the behavior of the Golgi apparatus in many animal cells.

The successful application of the methods here employed is as yet a matter largely of chance. The plastidome frequently blackens, but first-class results are only occasional. The spherome is almost always sharply impregnated, while the vacuome reacts very capriciously (frequently not at all). Furthermore, these elements may be impregnated singly or in any combination in a given cell. In general, an extensive series of serial preparations must be made in order to yield a few with really excellent fixation and impregnation.

The rather astonishing result has thus come out that methods of unusual selectivity for the Golgi material in animal cells, in plant cells will give positive results on a range of structural elements, including all known categories of cytoplasmic components (perhaps excepting central bodies). Thus all possible conclusions based on mere behavior toward osmic acid are seriously compromised from the very beginning.

The most pressing matter still remains of establishing the homologies presumably existent between the known series of cytoplasmic elements in plant and animal cells. My results incline me at present to accept the usual interpretation of the plastidome as equivalent to chondriosomes. I have followed all stages in the accumulation of starch (by the Benda and other methods) in the plastidome of root-cap, periblem and (less completely) plerome cells, and there can be no doubt as to the facts themselves. But as to interpretation, it appears that a definite conclusion must await some light on the actual functional significance of the chondriome in animal cells. The rôle of the presumed chondriome of plant cells as a center for carbohydrate synthesis suggests that in animal cells the chondriosomes may play a related part. Thus it becomes conceivable that the function of the chondriome may be found in carbohydrate metabolism, a hypothesis which might possibly be directly tested by a careful investigation of striated muscle fibers or liver cells.

With respect to the homologue of the vacuome in animal cells, it must be confessed that the pictures in periblem cells of Vicia are often astonishingly suggestive of the animal Golgi apparatus. Certain features of its behavior to technical treatment do not, however, tend to bear out the comparison. At present my results afford no critical demonstration one way or the other. But the capacity of the plant vacuome for staining with neutral red perhaps suggests some possible relation to structures similarly stainable in animal cells, and for which as yet no very satisfactory accounting has proved possible.

The spherome resembles in many ways the scattered Golgi bodies in certain animal cells. Further, the reaction to the osmic Golgi methods is usually positive, tends indeed to be fairly constant. Whether we can find in the spherome the homologue of the Golgi apparatus, as I suggested in my paper already referred to, must, however, remain uncertain pending the attainment of more critical criteria of judgment —possibilities of which I now have under investigation.

ROBERT H. BOWEN
DEPARTMENT OF ZOOLOGY,
COLUMBIA UNIVERSITY

THE USE OF SUBSCRIPT AND SUPERSCRIPT EXPONENTS IN MATHEMATICS AND IN CHEMISTRY[1]

SYSTEMS of notation are the tools of thought. A good workman is known by his tools, and to a greater extent than often is realized a good workman is such because of his tools. The extensive use of the abacus in countries, as ancient Rome or present-day China, whose people think in terms of symbols less convenient than the Hindu-Arabic notation, and the relatively great amount of time devoted to spelling in the schools of peoples whose writing is not phonetic,

[1] Presented before the Division of Physical and Inorganic Chemistry of the American Chemical Society at Washington, April, 1924.

testify to the needless burden which an unsatisfactory notation imposes on thought.

Notations, like tools, may be so cumbersome as to make the best workman awkward; they may be inadequate to the work they are intended to perform, or they may be so built that they will do much that they were intended not to do and work more harm than service. Notations can no more be absolutely protected against misconstruction than tools can be made entirely "fool-proof," yet in neither case is there any warrant for assuming unnecessary risks. The symbolism of related branches of knowledge should be as nearly uniform as the differences in content permit.

Subscripts and superscripts are used in logic, in algebra and in higher mathematics in a manner consistent enough to permit the generalization that subscripts are used to designate the various members of a series or group of related symbols; a_1, a_2, a_3; k_{12}, k_{14}, k_{23}, ∇_{124}, ∇_{123}, etc., while superscripts denote the same operation as would be represented by the repetition of the symbol to which the superscript (exponent) belongs a number of times indicated by the superscript:

$$a^2 \equiv aa,\ b^3 \equiv bbb,\ d^3(y) \equiv d(d(d(y))),$$
$$dx^3 \equiv dx\ dx\ dx,\ \nabla^2(\varphi) \equiv (\nabla \cdot \nabla)\ \varphi.$$

It would conduce to clearness of thought and ease of expression to preserve this distinction in the notations of arithmetic and of chemistry.

In arithmetic the value of a given digit depends on its position relative to units place, commonly indicated by the decimal point. The possible values of the digit then form an infinite geometric series of numbers, the ratio between successive terms being the base of numeration, that is, ten. If it be desired to designate a particular value of a digit, the principle stated above calls for the use of a subscript indicative of its position in the series. The logical starting point is units place, so that, *e.g.*, $3_0 \equiv 3.$, $4_1 \equiv 40.$, $6_3 \equiv 6000.$, $2_{-2} \equiv 0.02$. It is, of course, not necessary to indicate the position of every digit in a number expressed in the decimal notation, *e.g.*,

$$\pi \equiv 3_0 1_{-1} 4_{-2} 1_{-3} 6_{-4} \ldots,$$

since, if any one be indicated, the others are determined by position. Not only is it not necessary that units place be the one indicated, but in the many cases in which the units figure is not one of the significant figures, it is inconvenient, and even impractical, to indicate it. Thus to indicate units figure in a wave length of visible light, expressed in centimeters, would require the writing of four, or five, non-significant zeros; and the velocity of light, in centimeters per second, lacks six significant figures of reaching the decimal point, with the present experimental error of measurement.

The convention that a superscript is a shorthand way of indicating the repetition of a symbol would give, in arithmetic: $10^3 \equiv 1000$, $7^4 \equiv 7777$, $0.9^357 \equiv 0.99957$, $1/3 \equiv 0.3^\infty$. Only in the first case is the value the same as that given by an algebraic exponent, but *e.g.*, $10x \neq 107$ when $x = 7$. The use of a subscript to indicate repeated digits is fairly common, at least for the digits 0 and 9, but reasons for preferring the superscript for this meaning have already been given.

Comparing the proposed notation with that commonly used, *e.g.*, $c = 2_{10}9986 \equiv 2.9986 \times 10^{10}$, it can be seen that the latter requires the meaningless symbols, ., ×, and 10, meaningless because the first is the sign of units place, which the first significant figure in that number is not, the second of the multiplication of two numbers, in order to express one, and 10 is the symbol for *any* base of numeration.

In the case of temperature,[2] units place is ordinarily a significant figure, and, on the other hand, it is necessary to indicate in some manner which of several systems of stating temperatures is being used. This may be done by attaching to the units figure a subscript letter appropriate to the system: K for Kelvin (Centigrade absolute), C for Centigrade (Celsius), F for Fahrenheit, A for Fahrenheit absolute and R for Réaumur. Thus $310_K1 \equiv 37_C0 \equiv 98_F6 \equiv 558_A18 \equiv 29_R6$ would all represent the same temperature.[3] This mode of representation has the incidental advantage of obviating the possibility of confusion between a temperature and an angle, for example, of 60°.

In chemical symbols the suggested use of sub- and superscripts would give $H^2O \equiv HHO$, and would make Li_6 and Li_7 represent two different atomic species of the element lithium, the subscripts being, in this case, the atomic weights of the two known isotopes of lithium. The first usage is that of French chemists and of the German Chemiker Kalender, and the second has already been used to a considerable extent in spite of the obvious danger of confusion with the present subscript exponents. As an example of the notation proposed, consider a molecule of phosphorus pentachloride containing three atoms of the chlorine isotope of atomic weight 35, and two of the isotope of atomic weight 37. Its formula would be $PCl_{35}{}^3\,Cl_{37}{}^2$. It is becoming increasingly apparent that formulas for such compounds must be written, and the sooner the convention for such is established the less confusion there will be.

ELLIOT Q. ADAMS

NELA RESEARCH LABORATORY

2 This paragraph has been inserted since the paper was read.

3 "Normal" human mouth temperature.